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ABSTRACT

THE LAST THREE DECADES OF THE TWENTIETH CENTURY WILL WITNESS A DRASTIC CHANGE IN THE BUSINESS OF PROVIDING INSTRUCTION IN SCHOOLS AND COLLEGES. THE IDEA OF "INDIVIDUALIZED INSTRUCTION" HAS BEEN PURSUED IN A DESULTORY FASHION BY AMERICAN EDUCATORS FOR MOST OF THE CENTURY. THERE HAVE BEEN SEVERAL DIFFERENT CONCEPTS OF INDIVIDUALIZATION, THE MOST PREVALENT INTERPRETATION FOCUSING ON SELF-PACING CR RATE-TAILORING. THE IMPENDING INSTRUCTION REVOLUTION WILL SHORTLY BYPASS THE SIMPLEX IDEA OF INDIVIDUALIZING INSTRUCTION AND MCVE AHEAD TC THE MCRE SOPHISTICATED NOTION OF PROVIDING "ADAPTIVE INSTRUCTION" FOR SCHOOL AND CCLLEGE LEARNERS, WITH FOCUS ON THE TAILORING OF SUBJECT MATTER PRESENTATIONS TO FIT THE SPECIAL REQUIREMENTS AND CAPABILITIES OF EACH LEARNER. ESSENTIAL TO THE IDEA OF ADAPTIVE EDUCATION IS THE MEANS OF UTILIZING NEW KNOWLEDGE ABOUT INDIVIDUAL DIFFERENCES AMONG LEARNERS TC BRING A HIGHLY TAILORED INSTRUCTIONAL PRODUCT TC THE STUDENT VIA COMPUTER-ASSISTED INSTRUCTION IN WHICH MANY IDENTIFIABLE LEARNER VARIABLES ARE TAKEN INTO ACCCUNT. TWO CCNCCMITANTS TC THE REVCLUTION WHICH SERIOUSLY CONCERN COLLEGE FACULTY AND ADMINISTRATORS ARE ADAPTATION TO INCREASED HETEROGENEITY IN MENTAL ABILITY AND SCHOOL PREPARATION AMCNG COLLEGE STUDENTS AND A DRASTIC REVISION IN THE APPROACH TO LEARNER EVALUATION AND GRADING PRACTICES. STUDENT EVALUATION WOULD BE BASED ON THE CONCEPT THAT AN ACHIEVABLE MASTERY CRITERION EXISTS FOR EACH COURSE. (JS)

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THE IMPENDING INSTRUCTION REVOLUTION[1]

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First, I would like to explain the choice of the title, "The Impending Instruction Revolution." It is fashionable in these days of rhetorical excesses to describe change as revolutionary in scope. Television, Newspapers and magazines remind us daily that revolutions are occurring right under our noses. We hear of (and see) the Social Revolution, the Sexual Revolution, the Technology Revolution, the Student Revolt, the Faculty Revolt and so on. Apparently, any complete or sudden change in the conduct of human affairs, with or without a violent confrontation, may be called a revolution.

It is my thesis that the last three decades of the twentieth century will witness a drastic change in the business of providing instruction in schools and colleges. Change by the year 2000 will be so thoroughgoing that historians will have no difficulty in agreeing that it was a revolution. You will note the omission of words like "teaching" and "learning" in describing the coming revolution. Teaching connotes for most of us an inherently person-mediated activity and the vision of the "stand-up" lecturer comes most immediately to mind. One of the concomitants of the impending change is a drastic modification of the role of teacher. It is likely that future terms for teacher may be "instructional agent," or "lesson designer" or "instructional programmer." As far as learning is concerned, we take the position that learning is not a way of describing an <u>activity</u> of the student, but rather a way of characterizing change in the student's behavior in some desired direction

[1] Remarks presented at the 77th Annual Meeting of the American Society for Engineering Education held at University Park, Pennsylvania, June 24, 1969.

between two definite time markers. Pask (1969) has cogently pointed out that teaching is exercising control of the instructional environment by arranging the scope, sequence, materials, evaluation and content for students. In other words, instruction is the general term for the process and learning is the product.

My objective is to challenge you with the shape of the instruction revolution, point out how you as a teacher or administrator can cooperate and cope with it, and suggest some of the social changes which are currently fueling this revolution.

Individualized or Self-paced Instruction

At the secondary school level, American educators, beginning with Preston W. Search (1894) in the late nineteenth century, have been interested in the goal of individualization. Between 1900 and 1930, disciples of Frederick Burk (Brubacher, 1966, and Parkhurst, 1922) devised and implemented several laboratory-type plans for self-instruction in the lower schools. These were self-pacing plans for the learner and demanded a great deal of versatility on the part of the teacher. Additional impetus for the theoretical interest of educators in individualization stemmed from the mental testing movement, beginning with the seminal work of Binet (1916) about sixty years ago. Intelligence tests clearly showed differences in speed of task completion among pupils and these differences were easily confirmed by a teacher's own observations of mental agility. At the practical level, a great deal of individualization took place in rural America's one-room schools. Fifteen to twenty-five children spread unevenly through ages six to fourteen necessarily committed the "school marm," or schoolmaster, to large doses of individual pupil direction,

recitation and evaluation. With population increases and school consolidations, most small town and rural schools began to look like rigidly graded city schools. Teachers found themselves responsible for larger and larger groups of children of approximately the same age and about the same physical size. It is little wonder that some of the zest, enthusiasm and obviousness of need for individualized teaching was lost. When teachers complained about too large classes, the lack of time to spend with individual pupils, the wide diversity in pupil ability levels, many not-so-smart administrators introduced "tracking" or "streaming" strategies. Separating children into homogeneous classes according to measured mental ability within age groups has conclusively been shown to fail to increase the achievement level of groups as a whole (Goodlad, 1960). Homogeneous ability grouping has, on the other hand, seriously exacerbated social problems connected with race and economic levels by "ghettoizing" classrooms within the schools, even though the schools served racially and economically mixed neighborhoods.

Whereas the common schools have <u>some</u> history of experimentation with individualized instruction methods, higher education, led by the state universities, has pushed the development of mass communication methods in instruction. The large group lecture and the adaptation of closed-circuit television are examples of higher education's trend away from individualized instruction. Of course, the outstanding accomplishments of American university graduate schools could never have been achieved without the cost-savings introduced by mass communications techniques in their undergraduate colleges.

Interest in individualized instruction had a surge about fifteen years ago when Harvard's B. F. Skinner (1954, 1958) advocated an education technology built around the use of rather crude teaching machines. It soon became

apparent that there was no particular magic in the machines themselves since they contained only short linear series of questions and answers to word problems called "frames." These programs were quickly put into book form and the programmed text was born. Although it enjoyed initial success with some highly motivated learners, the programmed text has not "caught on" in either the lower schools or higher education as a major instructional device. Industry and the military forces seem to have made the best use of programmed texts, perhaps because of a high degree of motivation on the part of many learners in those situations.

More recently, an educational technique for the lower schools has been developed out of the work of the Learning Research and Development Center at the University of Pittsburgh. The method, called "Individually Prescribed Instruction," or IPI, is described by Lindvall and Bolvin (1967), by Glaser (1966) and by Cooley and Glaser (1968). Behind the method lies the careful development of a technology based on precise specification and delineation of educational objectives in behavioral terms. Pupils work individually on a precisely scaled set of materials with frequent interspersed diagnostic quizzes.

It must be clear, even after this sketchy review of the history of individualized instruction, that the concept has been pursued in a desultory fashion. I have heard hour-long dialogues by educators on the topic of individualization of instruction with each having only the vaguest notion of what is encompassed by the concept. Let me review five <u>different</u> concepts of individualization and acknowledge that I am indebted to Tyler (1967) for some of these distinctions.

First, most educators agree that instruction is "individual" when the learner is allowed to proceed through teaching materials <u>at a self-determined</u>

pace that is comfortable for him. This concept of self-paced instruction is incorporated into all programmed texts and is perhaps easiest to achieve with reading material and hardest to achieve in a setting that presents content by means of lectures, films and television. Oettinger (1969) in his witty, but infuriating, little book, Run, Computer, Run, refers to this self-pacing concept of individualization as "rate tailoring."

A second concept of individualized instruction is that the learner should be able to work at times convenient to him. The hard realities of academic bookkeeping with the associated paraphernalia of credits, marks and time-serving schedules make this concept difficult to implement in colleges or in the common schools.

That a learner should begin instruction in a given subject at a point appropriate to his past achievement is a third way of looking at individualization. This concept makes the assumption that progress in learning is linear and that the main task is to locate the learner's present position on a universal continuum. Once properly located, he can then continue to the goal. These notions seem to have their optimum validity for well ordered content like mathematics or foreign languages. In fact, the advanced placement program, which provides college credit for tested subject-matter achievement during secondary school, is a gross attempt to get at this kind of individualization.

A fourth concept of individualization is the idea that learners are inhibited by a small number of easily identifiable skills or knowledges. The assumption is that the absence of these skills is diagnosable and that remedial efforts through special instructional units can eliminate the difficulty. Colleges and universities seeking to enroll a higher proportion of their students from among the culturally disadvantaged and the economically deprived

will be forced to bring this concept to bear if they wish to maintain current academic standards.

A fifth concept is that individualization can be achieved by furnishing the learner with a wealth of instructional media from which to choose. Lectures, audio tapes, films, books, etc., all with the same intellectual content, could theoretically be made available to the learner. The underlying notion is that the learner will instinctively choose the communication medium or combination of media that enable him to do his best work. The research evidence to support this viewpoint and practice is not at all strong (Postlethwait, 1967). Perhaps even more persuasive than the lack of evidence is the vanity of instructors who cannot understand why a student would choose a film or an audio tape in preference to the instructor's own lively, stimulating and informative lectures (Tosti and Ball, 1969).

I have reviewed five concepts of individualization which have some credence in education, but far and away the prevalent interpretation is the one of self-pacing, or rate tailoring. These notions lead us directly to the idea of adaptive education in responsive environments which I want to discuss shortly. But first, one more distinction. "Individual instruction" where one studies in isolation from other learners should probably be distinguished from "individualized instruction" where the scope, sequence and time of instruction are tailored in one or more of the five ways I have just described. "Individualized instruction" can still be in a group setting and, in fact, was commonly practiced in rural one-room schools as mentioned earlier. On the other hand, "individual instruction" can be singularly rigid, monotonous and unresponsive to the needs of the learner. You could, for instance, take programmed text material which is designed for individualized instruction and

put it into an educational television format. Each frame could be shown to a large group of students for a short time, allowing the students to pick a correct option and then going on to another frame. This procedure would be individual instruction with a vengeance. But it forces a kind of lock-step on the students of varying abilities and interests that is the antithesis of "individualized instruction."

Adaptive Education

I predict that the impending instruction revolution will shortly bypass the simplex idea of individualizing instruction and move ahead to the more sophisticated notion of providing adaptive education for school and college learners. By adaptive education, we mean the tailoring of subject-matter presentations to fit the special requirements and capabilities of each learner. The ideal is that no learner should stop short of his ultimate achievement in an area of content because of idiosyncratic "hang-ups" in his particular study strategies.

We have seen how the concept of individualized instruction has been pretty well arrested at the level of encouraging the learner to vary and control his task completion time. Many additional, more psychologically oriented variables will have to be brought into play to achieve the goals of adaptive education, as well as the adoption of individualizing techniques. We know a great deal about individual differences among people in regard to their sensory inputs, their reaction times, their interests, their values and preferences, and their organizational strategies in "mapping" the cognitive world. What we do not know very much about is the extent to which, or how, these easily tested, individual difference variables affect the acquisition and retention of new knowledge. Psychological learning theory has been preoccupied

with the study of variables in extremely simple, stimulus-response situations, and investigations of meaningful learning phenomena have clearly dealt with human subjects as if they were all cut from the same bolt. The exception to this observation is, of course, the variable of measured mental ability which has been shown to be related to achievement in conventionally presented instruction and has been carefully controlled in many learning experiments involving human subjects.

Essential to the idea of adaptive education is the means of utilizing new knowledge about individual differences among learners to bring a highly tailored instructional product to the student. As long as we are dealing with static or canned linear presentations such as those contained in books, films, video tapes and some lectures, there seems to be little incentive to try to discover what modifications in instructional materials would optimize learning for each student. To plug this important gap in the drive toward vastly improved learning, the modern digital computer seems to have great promise. About a decade ago, Rath, Anderson and Brainerd (1959) suggested the application of the computer to teaching tasks and actually programmed some associative learning material. In the intervening decade, a number of major universities, medical schools, industries, and military establishments have been exploring the use of the computer in instruction. Five years ago, we instituted a Computer Assisted Instruction Laboratory here at Penn State and have been trying to perfect new instructional techniques within the constraints of available hardware and computer operating systems (Mitzel, 1967; Mitzel, Brown and Igo, 1968; Mitzel, 1968; Inquiry, 1967). There are, according to my estimate, some thirty-five to forty active CAI installations operating in the world today, and fewer than one hundred completed, semester-length courses or

equivalent. Almost none of these courses have been constructed according to the ideals I mentioned for adaptive education. Indeed, many of them look like crude, made-over versions of programmed textbooks, but this does not disturb me when I recall that the earliest automobiles were designed to look like carriages without the horses. The fact is that the modern computer's information storage capacity and decision logic have given us a glimpse of what a dynamic, individualized instruction procedure could be, and some insight into how this tool might be brought to bear to achieve an adaptive quality education for every student. We do not claim that the achievement of this goal is just around the corner, or that every school and college can implement it by the turn of the century. We do believe that progress toward a program of adaptive education will be the big difference between our best schools and our mediocre ones at the end of the next three decades.

What individual difference variables look most promising for adapting instruction to the individual student via CAI? At Penn State, we are testing the idea that a person learns best if he is rewarded for correctness with his most preferred type of reinforcement (Cartwright & Cartwright, 1969). Thus, some students will, we believe, learn more rapidly if they receive encouragement in the form of adult approval. Others will perform better if they receive actual tokens for excellence at significant places in the program, the tokens being exchangeable for candy, "cokes," or other wanted objects. Still others respond to competitive situations in which they are given evidence of the superiority or inferiority of their performance compared to that of their peers. It is a fairly simple matter to determine a learner's reward-preference in advance of instruction and to provide him with a computer-based program in which the information feedback is tailored to this psychological preference.

Perhaps the most dynamic and relevant variable on which to base an adaptive program of instruction is the learner's immediate past history of responses. By programming the computer to count and evaluate the correctness of the ten most recent responses, what comes next for each learner can be determined according to a prearranged schedule. For example, four or less correct out of the most recent ten might dictate branching into shorter teaching steps with heavy prompting and large amounts of practice material. A score of five to seven might indicate the need for just a little more practice material, and eight or more correct out of the ten most recent problems would suggest movement onto a fast "track" with long strides through the computer-presented content. The dynamic part of this adaptive mechanism is that the computer constantly updates its performance information about each learner by dropping off the learner's response to the tenth problem back as it adds on new performance information from a just completed problem.

There are two rather distinct strategies for presenting subject matter to learners. One is <u>deductive</u> in which a rule, principle or generalization is presented, followed by examples. The other strategy is <u>inductive</u> and seeks, by means of a careful choice of illustrative examples, to lead the learner into formulating principles and generalizations on his own initiative. In the lower schools, inductive method is called "guided discovery" and has been found useful by many teachers. Our belief at the CAI Laboratory is that these two presentation strategies have their corollaries in an individual differences' variable and that, for some students, learning will be facilitated by the deductive approach; others will learn more rapidly and with better retention if an inductive mode is adopted. Now, it is altogether likely that, if you used a methods-comparison strategy for assessing the relative effectiveness of

deductive and inductive instructional materials and ignored heterogeneity among students, you would find no difference between the two approaches. The principal reason for this finding, as with so much of the study of educational methods, is that some, say, about one-half of the students, learn better under one mode and the other half improves optimally with the second method, thus cancelling out an instructional methods' effect when individual differences are ignored (Riedesel & Suydam, 1967; Siegel, 1969). A strong program of adaptive education would take these and other identifiable learner variables into account in the instructional process.

Educational Evaluation and Student Appraisal

One of the important concomitants of the instruction revolution will be a drastic revision in the approach to learner evaluation and grading practices by faculty. Even the moderate students on campus are saying that letter grades are anachronistic. On many campuses, including our own, students have petitioned for, and won, the right to receive "satisfactory" and "unsatisfactory" evaluations of their work in certain non-major courses. Other students have attacked all grades as a manifestation of a coercive, competitive, materialistic society. Without admitting to being a tool of a sick society, this is one part of the business of higher education that we could, and should, change as rapidly as possible.

It seems to me that most formal instruction has been predicated on the notion that a course is offered between two relatively fixed points in time. In addition, the tools of instruction, such as lectures, textbooks, references and computer services, are all relatively fixed and are the same for all learners. To be sure, the students do vary the amount of time they spend with these tools. Even there, the college catalogue tells the students that they

should all study three hours outside of class for every hour in class. At the close of the period of instruction or end of the course, usually the end of the term, we give the students an achievement test that is constructed in a way that will maximize the differences among their scores. To get this seemingly important differentiation between our students in achievement, we have to ask extremely difficult questions. Sometimes we even go so far as to ask questions about footnotes in the text. In fact, we often have to ask questions on topics or objectives that we have made no attempt to teach Our rationalization for this tactic is that we want the students to be able to transfer their knowledge. After obtaining the achievement examination results, we consult the trusty "normal curve" and assign A's, B's, C's, D's and F's according to our interpretation of the grading mores of the institution. With time and materials fixed, we are essentially capitalizing upon the same human abilities that are measured by intelligence tests. Thus, it is not surprising that intelligence and teacher-assigned grades tend to be highly correlated.

We could, as collegiate educators, do society and ourselves a big favor by making a fundamental shift in our approach to teaching and examining. Incidentally, we might generate some relevance "points" with our students. First, we should say (and mean) that our job is helping each of our students to achieve mastery over some operationally defined portion of subject matter (Bloom, 1968). Furthermore, failure to achieve mastery by any student putting forth an effort is a failure on our part as teachers, or a breakdown of the selection system. Now, to do this job, we will have to get rid of a lot of the present practices and irrelevancies of higher education. There is no point in maintaining an adversary system in the classroom with the students against the instructor and each of the students against each other. Society

may think that it wants us to mark our students on a competitive scale, but how much more relevant it would be if we could say, on the basis of accumulated examination evidence, that John Jones has achieved eighty-five per cent of the objectives in Engineering 101, rather than say that John Jones got a "B" in Engineering 101. If our job is to help the student master the subject matter or come close, say, achieve ninety per cent or greater of the objectives, then we are going to have to adapt our instruction to him. As a starter, we could individualize by letting the student pace his own instruction. We know, for example, from preliminary work with class-sized groups in computer-assisted instruction, that the slowest student will take from three to five times as long as the fastest student in a rich environment of individualized teaching material. During a recent computer-mediated inservice teacher education course presented by Penn State in Dryden, Virginia, to one hundred and twenty-nine elementary school teachers, the average completion time was 21 clock hours. The fastest student finished in 12 hours and the slowest student took 58 hours (Hall, Mitzel, Riedesel, Suydam & Trueblood, 1969).

In addition to rate tailoring or individualization of instruction, our student evaluations should be based on the concept that an achievable mastery criterion exists for each course. No longer should we engage in the sophistry of classical psychometrics in which we prepare a test or examination deliberately designed to make half the students get half the items wrong. It is true that such a test optimally discriminates among the learners, which is in turn justified by the assumed need for competitive marking information. If, however, 50 per cent of the students get 50 per cent of the items wrong, then either we are asking the wrong questions or there is something seriously wrong with our non-adaptive instructional program.

Under optimum circumstances, we might get an enlightened view of the need on the part of faculty to adopt mastery-type student evaluation procedures and we might get professors to talk less, but we would still be faced with the psychological problem of instructor dominance or instructor power. The power over students which the "giving" of grades confers on professors would not be yielded easily by many in college teaching today. As Pogo is alleged to have said, "We have met the enemy and he is us."

If we, as faculty and administrators in higher education institutions, embraced the notion of teaching for student mastery by means of individually adaptive programs, then these are some of the concomitants:

(1) Instructors would have to state their course objectives in behavioral terms.

(2) Achievement tests keyed to course objectives would have to be constructed and used as both diagnostic placement and end-of-course determiners.

(3) The bachelor's degree might take from two to eight years instead of the traditional four years, because of the wide variability in mastery achievement.

(4) Instead of telling three times a week, instructors might have to spend their time listening to students individually and in small groups where progress toward subject mastery required careful monitoring.

(5) Instead of being primarily concerned with a discipline or with a specialization, those who profess for undergraduates would have to have the student and his knowledge as their first concern.

(6) Evaluation for promotion and salary increments for college teachers would be based on measured amounts of growth exhibited by their students and on numbers of students who achieved a specific mastery criterion.

You can, I'm sure, think of additional apocalyptic changes in the undergraduate scenario which would and should result from a serious attempt to implement adaptive education as an aspect of the instruction revolution.

In the current wave of student unrest, many of the best articulated issues are local in nature, like the quality of food in the cafeteria or the relaxation of dormitory visiting rules for members of the opposite sex. Underneath these surface issues, however, lies the <u>one big issue</u>, which the students themselves haven't spelled out clearly. This is the issue of the relevance of contemporary collegiate instruction for students' lives. It seems to me students are saying, albeit not very clearly, that they want some wise adult to care about them, to pay attention to them, to listen and to guide them. We sit on our <u>status quo's</u> and ignore their cry for help at our peril.

<u>Increasing Heterogeneity among Students</u>

Part of the fuel for breeding the revolution in instruction is the increasing heterogeneity in mental ability and scholastic preparation among college students. The combined power of the teaching faculty, the regional accrediting agencies, and the shortage of spaces for students has, until recently, enabled many public universities to become increasingly selective. In fact, prestige among higher education institutions has been closely correlated with the height of the norms for entrance test scores. Even the great state universities, which began under the land-grant aegis as people's colleges, have a kind of "elitest" aura about them. Increased aspirations of minority groups,

particularly blacks, have pointed up the fact that the poor, the disadvantaged, and the dark-skinned of our society do not share equally in whatever benefits a post-secondary college experience confers upon our citizens. The recent study and report by Dr. John Egerton for the National Association of State Universities and Land-Grant Colleges (Nelson, 1969) was based on eighty public universities which enroll almost one-third of the nation's college students. He found that less than two per cent of the graduate and undergraduate students were Negro in these eighty institutions and that less than one per cent of the faculty are black. On the other hand, approximately eleven per cent of the people are black. It seems irrefutable that, with society's new awareness of the inequality in higher education, university entrance standards will have to be lowered for sizeable groups of blacks who have been poorly educated in the nation's secondary schools. Newspaper accounts of City University of New York's open enrollment plan for Fall of 1970 provide ample proof of the beginning of this trend. The lowering of entrance requirements will inevitably increase the heterogeneity of scholastic skills which makes the traditional teaching job so difficult.

Another source for increasing individual differences among college undergraduates is their stiffening resistance to <u>required</u> courses. Students clearly want more freedom of choice in devising their education programs. They want to determine what subjects are relevant to their lives and are increasingly impatient with elaborate prerequisites and multi-course sequences. Although the activists are not likely to win a complete victory on this score, the pressure which they generate will serve to breach the walls and gates around courses that have carefully been built by faculty over the years in order to make the conventional job of teaching somewhat more manageable. In

addition to the student rejection of required courses, there is a corresponding need for the teaching of interdisciplinary subjects. Students see, perhaps more clearly than the faculty, that solution of the nation's problems such as urban decay, congestion, air and water pollution, and war and peace are not going to be solved by the unitary application of knowledge from traditional disciplines. For purposes of this discussion, the drive toward more interdisciplinary courses of study can only increase the heterogeneity among students which the faculty has labored to minimize.

Conclusion

In conclusion, I have argued that we are now living with the early stages of a revolution in instruction which will be more or less complete by the turn of the century. The shape of the major changes will be primarily characterized by individualization of instruction leading to sophisticated systems of adaptive education. Two concomitants of the revolution which seriously concern college faculty and administrators are the need for new fundamental concepts of student appraisal and adaptation to increasing heterogeneity among the students in our charge.

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